كلية التقنية الالكترونية ـ طرابلس
قسم الإتصالات
د. محمد عبدالله سعيد

المادة: إتصالات II
الامتحان النهائي ربيع 2019
الزمن: ساعتان

الإجابة النموذجية

Q1: (8 Marks)

Put true or false for each sentence and correct the false one:

1. A correlator is type of matched filter..... ✓
2. Quantization noise error can be reduced by increasing the quantization levels..... ✓
3. Noncoherent detection means detection with carrier phase information..... X

   Noncoherent detection means detection without carrier phase information.
4. If $\frac{\Delta f}{B} \ll 1$ we have FSK wideband system and if $\frac{\Delta f}{B} > 1$ we have narrowband FSK system..... X

   If $\frac{\Delta f}{B} \ll 1$ we have narrowband FSK system and if $\frac{\Delta f}{B} > 1$ we have wideband FSK system.
5. BPSK and QPSK do not have the same bit-error probability..... X

   BPSK and QPSK have the same bit-error probability
6. A channel can typically be modeled as a linear filter with addition of noise..... ✓
7. For orthogonal FSK signaling, tones must have a frequency separation that is multiple of 1/(2T) Hz. X

   For orthogonal FSK signaling, tones must have a frequency separation that is multiple of 1/T Hz.
8. Spread spectrum modulation can be used to minimize the effect of interference..... ✓

Q2:

a) What are the advantages of digital modulation? **(4 Marks)**

1. More robust the analog to noise and interference.
2. More viable to using regenerative repeaters.
3. Digital hardware more flexible by using microprocessors and VLSI.
4. Can be coded to yields extremely low error rates.
5. Easier to multiplex several digital signals.
6. More efficient in SNR for bandwidth.
7. Easily encrypted for security.
8. Digital signals storage is easier, cheaper and more efficient.
9. Reproduction of digital data is more reliable without deterioration.
10. Cost is coming down in digital systems.

b) Find the modulation rate and the bandwidth required for transmission data with a 8-PSK system using 24Mb/s and a carrier frequency of 160MHz? **(4 Marks)**

Answer:

$$M = 8 = 2^3 = 2^n$$

$$n = log_2(8) = 3 \text{ bits}$$

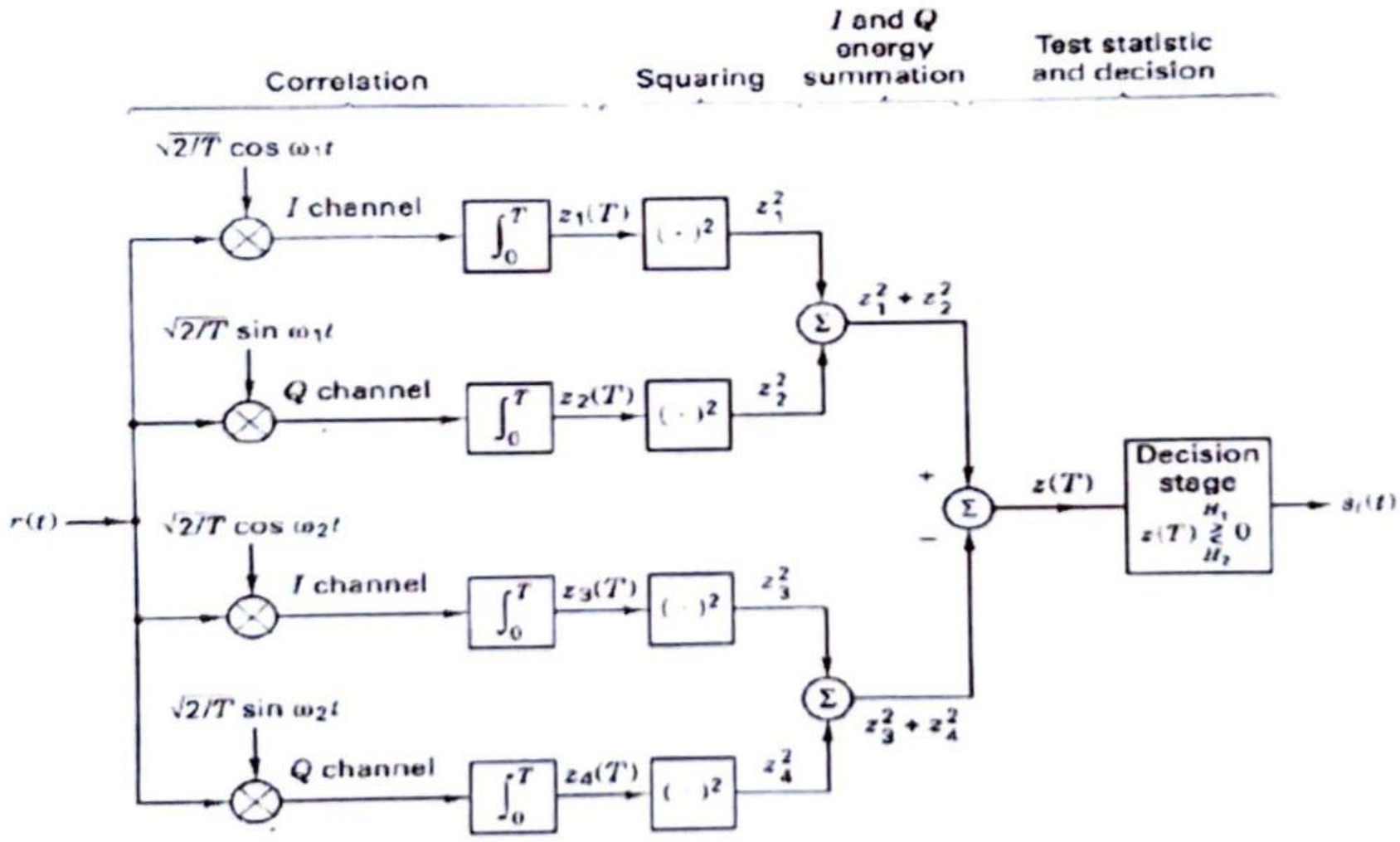
$$D = \frac{R}{n} = \frac{24 \times 10^6}{3} = 8\,M\,bauds/sec$$

$$D = 2W,$$

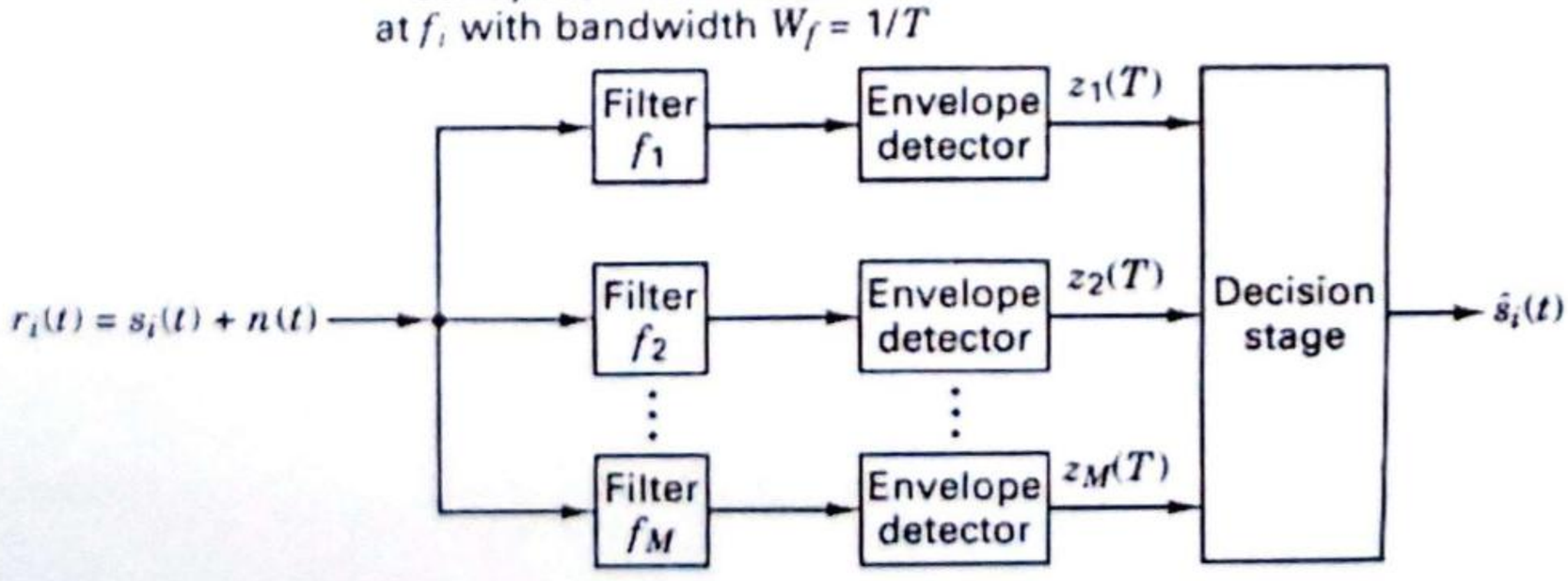
$$W = \frac{D}{2} = \frac{8 \times 10^6}{2} = 4\,MHz$$

Q3:

a) Draw a noncoherent Binary FSK receiver? **(4 Marks)**



Or



b) Show how to generate and detect a DPSK signal for the binary sequence b_k: **(4 Marks)**

$\{b_k\}$		**1**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**1**	**1**
$\{d_{k-1}\}$		1	1	0	1	1	1	0	1	0	0
$Differentially\ encoded\ sequence\{d_k\}$	1	1	0	1	1	1	0	1	0	0	0
Transmitted phase (radians)	0	0	π	0	0	0	π	0	π	π	π
Sampler's output Polarity		+	-	-	+	+	-	-	-	+	+
Decision-maker's output		1	0	0	1	1	0	0	0	1	1

Q4:

A band limited signal m(t) of 6 MHz bandwidth is sampled at rate of $66\frac{1}{6}\%$ higher than the Nyquist rate. The maximum allowable error in the sample amplitude is 0.15% of the peak amplitude m_p. Assume binary encoding. Find the minimum bandwidth of the channel to transmit the encoded binary signal? If 8 such signals are time multiplexed on a single line, What are the capacity and the bandwidth of this line? **(8 Marks)**

Answer:

The Nyquist frequency is $f_N = 2 \times 6 \times 10^6 = 12 \times 10^6\ Hz\ (samples/second)$, the actual rate is $66\frac{1}{6}\%$ higher, so that:

$$f_s = 12 \times 10^6\ Hz + (0.662 \times 12 \times 10^6 Hz) \approx 20 \times 10^6 Hz\ (samples/second)$$

The quantization step is Δv and the maximum quantization error is plus/minus $\Delta v/2$.

$$\frac{\Delta v}{2} = \frac{m_p}{L} = \frac{0.15}{100} m_p$$

$$L \approx 667$$

For binary coding, L, must be power of two, Knowing that $L = 2^9 = 512$ and $L = 2^{10} = 1024$.

So we choose $n = 10$ to guarantee better than 0.15% error.

Total number of bits per second: $C = 10\ bits \times 20 \times 10^6 = 200M\ bits/seconds$

We can transmit 2 $bits/Hz$ of bandwidth, then:

The required bandwidth: $B_T = \frac{C}{2} = 100\ M\ Hz$

If 8 signals are time multiplexed on a single line, then the line capacity:

$$C_T = 8 \times 200 \times 10^6 bits/s = 1600 \times 10^6\ bits/seconds$$

$$= 1.6\ G\ bits/seconds$$

The bandwidth: $B_T = \frac{C}{2} = 800\ M\ Hz$

Q5: Compare the average power requirements of a binary PSK, DPSK and noncoherent FSK schemes operating at a data rate of 1k bits/sec over a bandpass channel having a bandwidth of 3k Hz and the noise PSD at the receiver inputs is $\frac{\eta}{2} = 10^{-10}$ W/Hz, and $P_e = 10^{-5}$. Give your comments on the answer. **(8 Marks)**

For PSK:

$$P_e = \frac{1}{2} erfc\left(\sqrt{\frac{S_{av} T_b}{\eta}}\right) \leq 10^{-5}.$$

$$erfc\left(\sqrt{\frac{S_{av}}{2 * 10^{-10} * 10^3}}\right) \leq 2 * 10^{-5}$$

Thus $\frac{S_{av}}{2*10^{-7}} \geq 9.094$

$$\boldsymbol{S_{av} \geq 1.82\,\mu W \ \ or \ \ S_{av} = -27.4\,dBm}$$

For DPSK:

$$P_e = \frac{1}{2} exp\left(-\frac{A^2 T_b}{2\eta}\right) = exp\left(-\frac{S_{av} T_b}{\eta}\right) \leq 2 * 10^{-5}$$

Thus $exp\left(-\frac{S_{av}}{2*10^{-7}}\right) \leq 2 * 10^{-5}$

$$\boldsymbol{S_{av} \geq 2.16\,\mu W \ \ or \ \ S_{av} = -26.6\,dBm}$$

It can be seen that PSK needs 1dB average power less than DPSK for the same probability of error.

For noncoherent FSK:

$$P_e = \frac{1}{2} exp\left(-\frac{A^2 T_b}{8\eta}\right)$$

$$P_e = \frac{1}{2} exp\left(-\frac{A^2 T_b}{8\eta}\right)$$

$$P_e = \frac{1}{2} exp\left(-\frac{S_{av} \cdot T_b}{4\eta}\right) \leq 10^{-5}$$

Thus $exp\left(-\frac{S_{av}}{8*10^{-7}}\right) \leq 2 * 10^{-5}$

$$\boldsymbol{S_{av} \geq 8.665\,\mu W \ \ or \ \ S_{av} = -20.6\,dBm}$$

That is mean NFSK needs 6dB average power more than DPSK for the same probability of error.

$\operatorname{erfc}(\sqrt{x})$	x	$\operatorname{erfc}(\sqrt{x})$	x	$\operatorname{erfc}(\sqrt{x})$	x	$\operatorname{erfc}(\sqrt{x})$	x
9×10^{-1}	0.007895	9×10^{-4}	7.667845	9×10^{-9}	16.529043	9×10^{-13}	25.525168
8×10^{-1}	0.032092	8×10^{-4}	7.779146	8×10^{-9}	16.637556	8×10^{-13}	25.641072
7×10^{-1}	0.074236	7×10^{-4}	7.905424	7×10^{-9}	16.767404	7×10^{-13}	25.772145
6×10^{-1}	0.137498	6×10^{-4}	8.051325	6×10^{-9}	16.917335	6×10^{-13}	25.923472
5×10^{-1}	0.227468	5×10^{-4}	8.224055	5×10^{-9}	17.094711	5×10^{-13}	26.102474
4×10^{-1}	0.354163	4×10^{-4}	8.435695	4×10^{-9}	17.311866	4×10^{-13}	26.321584
3×10^{-1}	0.537097	3×10^{-4}	8.708911	3×10^{-9}	17.591929	3×10^{-13}	26.604113
2×10^{-1}	0.821187	2×10^{-4}	9.094647	2×10^{-9}	17.986844	2×10^{-13}	27.002402
1×10^{-1}	1.352772	1×10^{-4}	9.755711	1×10^{-9}	18.662447	1×10^{-13}	27.683512
9×10^{-2}	1.437187	9×10^{-5}	9.856363	9×10^{-10}	18.765192	9×10^{-14}	27.787068
8×10^{-2}	1.532451	8×10^{-5}	9.968934	8×10^{-10}	18.880068	8×10^{-14}	27.902841
7×10^{-2}	1.641510	7×10^{-5}	10.096618	7×10^{-10}	19.010323	7×10^{-14}	28.034103
6×10^{-2}	1.768692	6×10^{-5}	10.244100	6×10^{-10}	19.160717	6×10^{-14}	28.185646
5×10^{-2}	1.920729	5×10^{-5}	10.418644	5×10^{-10}	19.338631	5×10^{-14}	28.364901
4×10^{-2}	2.108942	4×10^{-5}	10.632424	4×10^{-10}	19.556431	4×10^{-14}	28.584317
3×10^{-2}	2.354646	3×10^{-5}	10.908279	3×10^{-10}	19.837306	3×10^{-14}	28.867233
2×10^{-2}	2.705947	2×10^{-5}	11.297521	2×10^{-10}	20.233329	2×10^{-14}	29.266055
1×10^{-2}	3.317448	1×10^{-5}	11.964063	1×10^{-10}	20.910728	1×10^{-14}	29.948044
9×10^{-3}	3.411413	9×10^{-7}	12.065497	9×10^{-11}	21.013737	9×10^{-15}	30.051730
8×10^{-3}	3.516737	8×10^{-7}	12.178926	8×10^{-11}	21.128904	8×10^{-15}	30.167647
7×10^{-3}	3.636484	7×10^{-7}	12.307565	7×10^{-11}	21.259485	7×10^{-15}	30.299072
6×10^{-3}	3.775151	6×10^{-7}	12.456124	6×10^{-11}	21.410252	6×10^{-15}	30.450801
5×10^{-3}	3.939719	5×10^{-7}	12.631910	5×10^{-11}	21.588599	5×10^{-15}	30.630273
4×10^{-3}	4.141908	4×10^{-7}	12.847166	4×10^{-11}	21.806920	4×10^{-15}	30.849952
3×10^{-3}	4.403731	3×10^{-7}	13.124855	3×10^{-11}	22.088452	3×10^{-15}	31.133201
2×10^{-3}	4.774768	2×10^{-7}	13.516556	2×10^{-11}	22.485373	2×10^{-15}	31.532483
1×10^{-3}	5.413783	1×10^{-7}	14.186994	1×10^{-11}	23.164238	1×10^{-15}	32.215232
9×10^{-4}	5.511380	9×10^{-8}	14.289989	9×10^{-12}	23.267462	9×10^{-16}	32.319030
8×10^{-4}	5.620616	8×10^{-8}	14.403035	8×10^{-12}	23.382868	8×10^{-16}	32.435073
7×10^{-4}	5.744623	7×10^{-8}	14.532363	7×10^{-12}	23.513717	7×10^{-16}	32.566638
6×10^{-4}	5.887989	6×10^{-8}	14.681703	6×10^{-12}	23.664789	6×10^{-16}	32.718529
5×10^{-4}	6.057833	5×10^{-8}	14.858393	5×10^{-12}	23.843492	5×10^{-16}	32.898190
4×10^{-4}	6.266097	4×10^{-8}	15.074727	4×10^{-12}	24.062243	4×10^{-16}	33.118096
3×10^{-4}	6.535197	3×10^{-8}	15.353760	3×10^{-12}	24.344317	3×10^{-16}	33.401635
2×10^{-4}	6.915542	2×10^{-8}	15.747279	2×10^{-12}	24.741981	2×10^{-16}	33.801318
1×10^{-4}	7.568353	1×10^{-8}	16.420627	1×10^{-12}	25.422064	1×10^{-16}	34.484730

مع تمنياتي للجميع بالتوفيق